

ERBS Tilted Nonscanner Update

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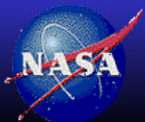
Team

Robert B. Lee, III (instrument), G. Louis Smith (TOA inversion),
Kathy Bush, and Dianne Snyder (data management and production),
Takmeng Wong (data validation)

CERES Science Team Meeting

Hampton, Virginia

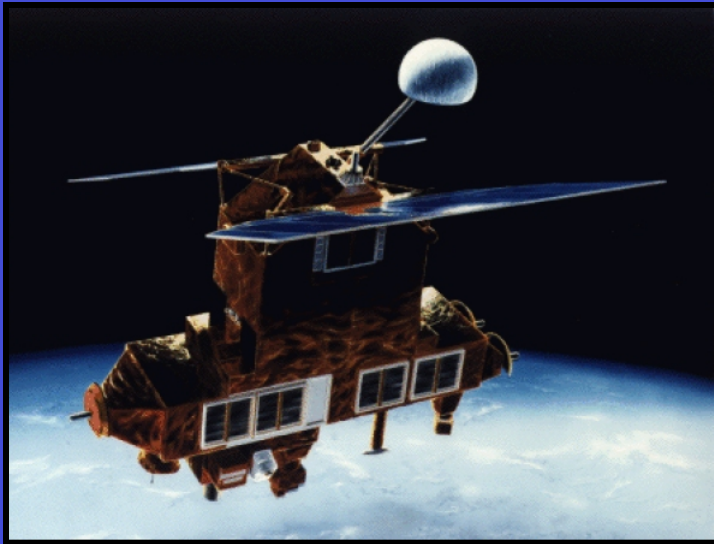
5-7 May, 2015



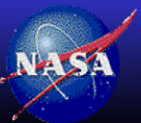
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History of ERBS Nonscanner Record



- ERBE nonscanner is one of the scientific instruments on the ERBS spacecraft
 - ERBS was deployed and Launched on the Space Shuttle Challenger on 10/5/1984
 - Retired on 10/14/2005 after 21-year of service
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- The ERBE/ERBS nonscanner operated nominally from 11/1984 to 9/1999; giving a high quality 15-year radiation budget (SW, LW, and Net) data set
 - The ERBE/ERBS nonscanner record after 9/1999 is not released to the publics due to instrument anomaly occurred on 10/5/1999
 - The missing 6-year ERBE/ERBS nonscanner data record (10/99 to 8/2005), if it can be recovered, can be very useful in tying the ERBE and the CERES SW record together



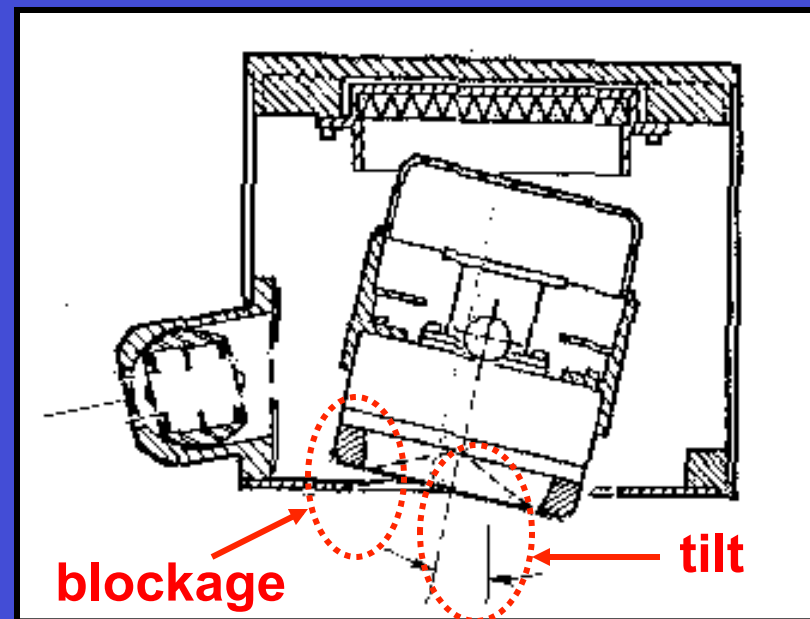
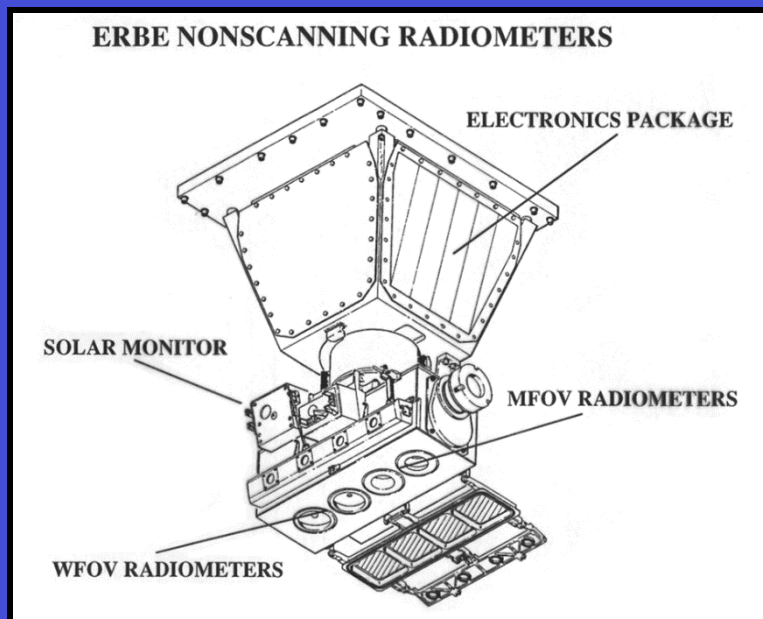
Outlines

- Provide a description of the ERBS instrument anomaly that occurred on 10/5/1999 and how this affected the SW science data
- Highlight steps that we have taken to recover the last five years of ERBS nonscanner SW data record
- Show SW validation results between the recovered ERBE/ERBS data record and the CERES SYN1deg data



Description of the ERBS Instrument Problem

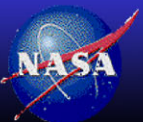
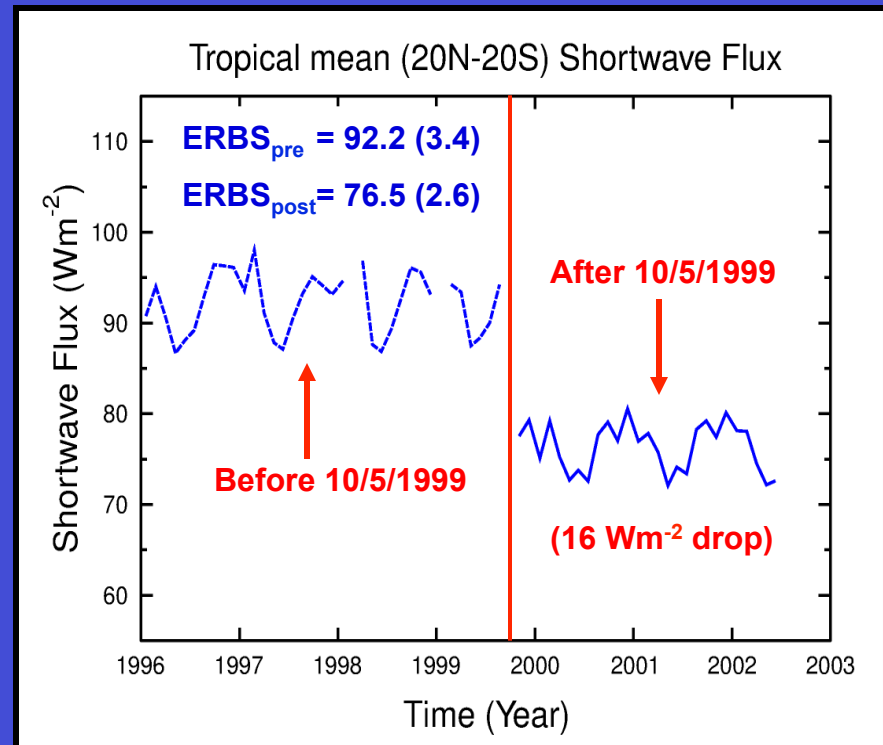
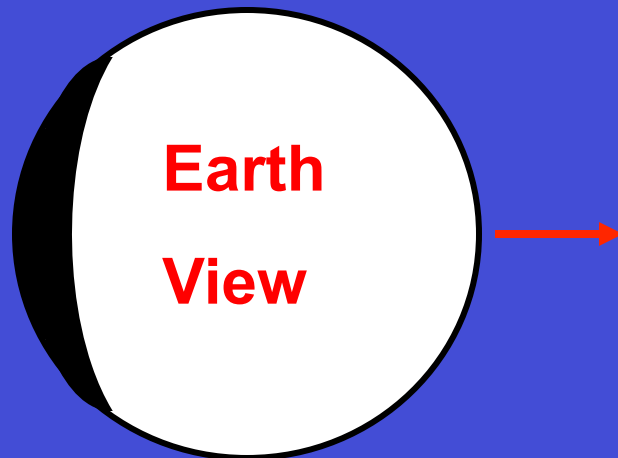
- ERBS nonscanner anomaly occurred on 10/5/1999 at the end of its calibration event with instrument stuck at an angle away from nadir
- Sensor FOV is partially blocked by the instrument housing
- Revised algorithm is required to remove this instrument tilt anomaly artifact from the ERBS scientific data record after 10/5/1999



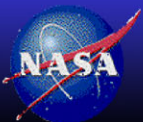
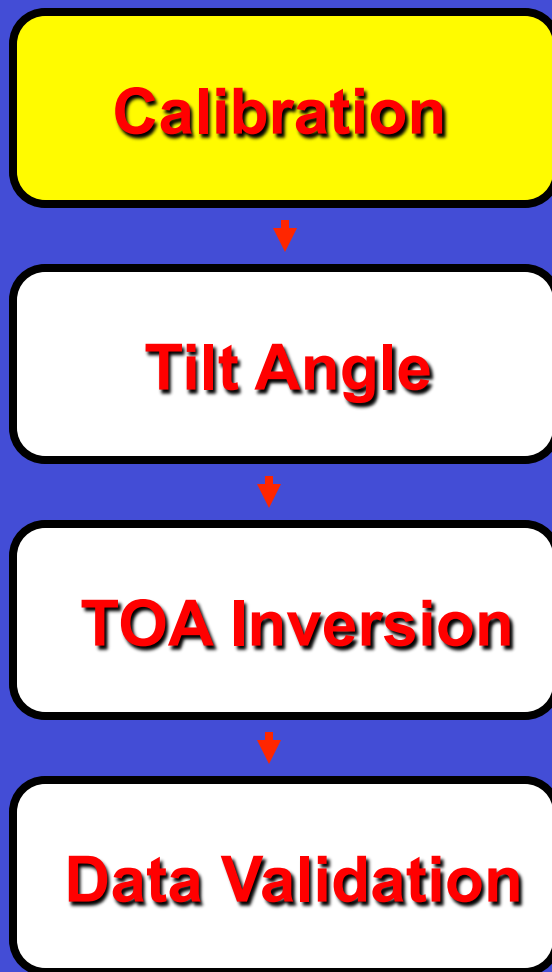
Instrument Tilt Anomaly Artifact

- The effect of the instrument tilt anomaly, if not corrected, will appear as a sharp drop in the reflected shortwave fluxes after 10/5/1999

**ERBS Earth-viewing
footprint with tilted sensor**

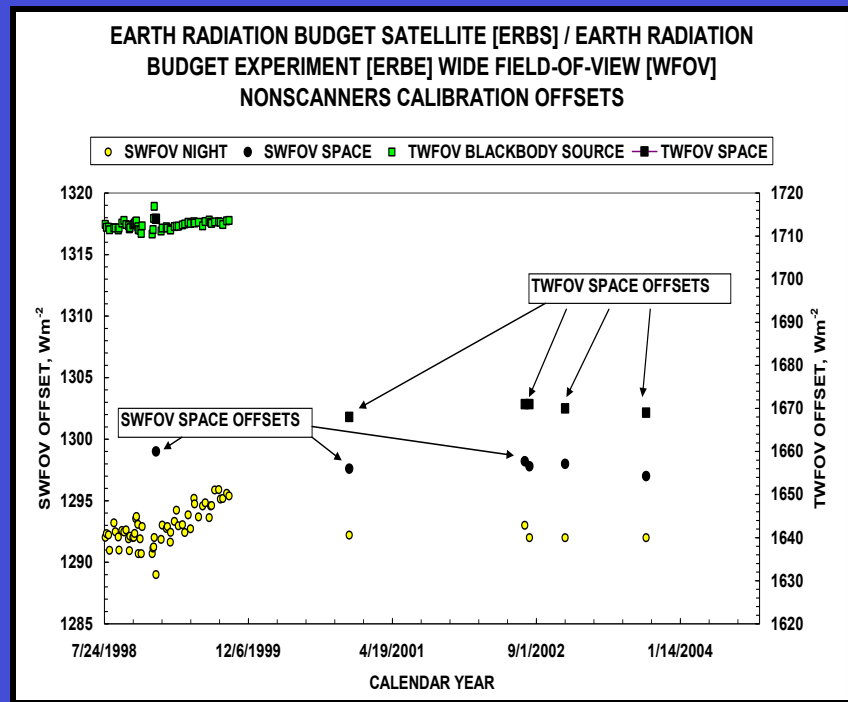
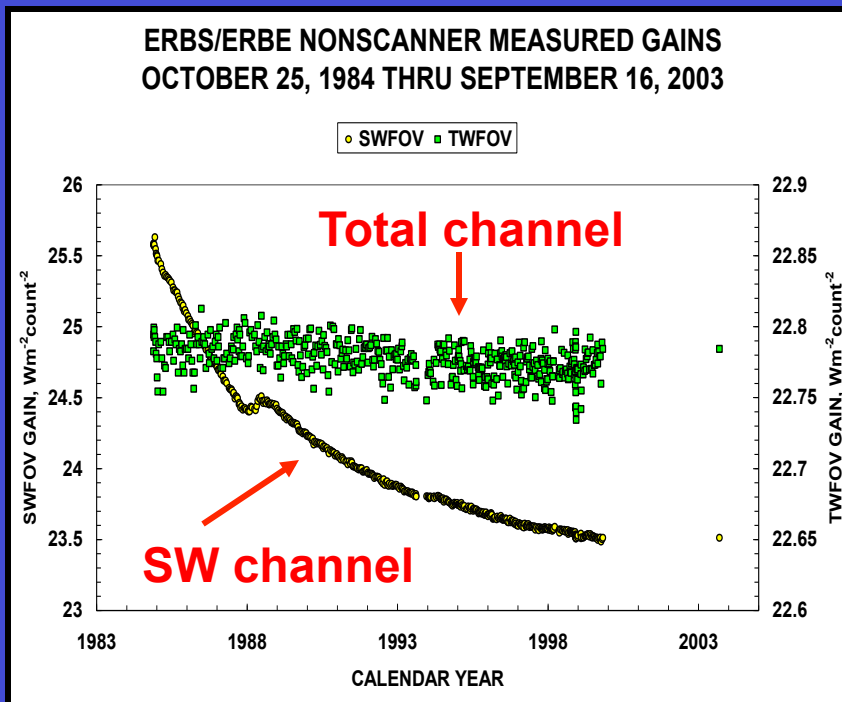


ERBS Data Recovery Processes

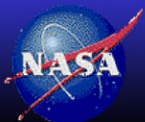
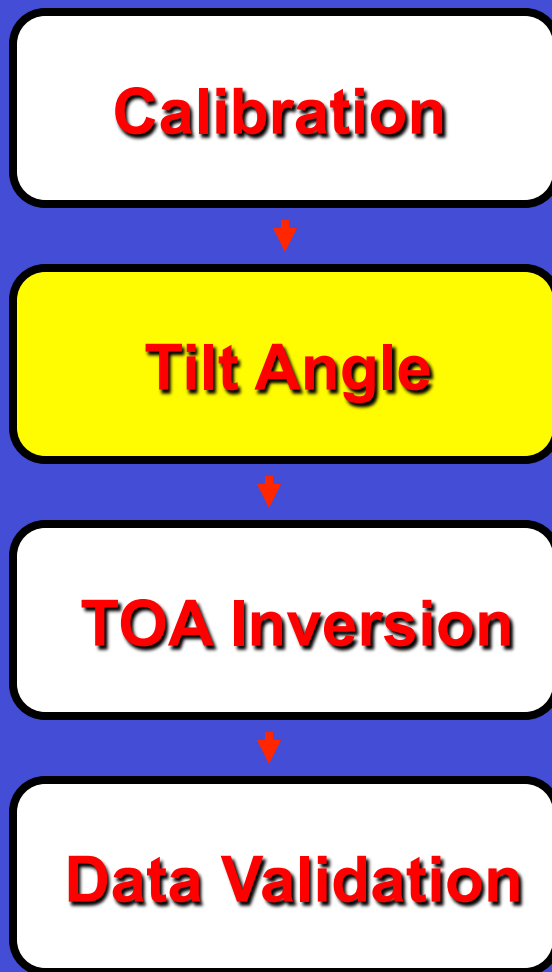


Instrument Calibration (Gain and Offset)

- ERBS nonscanner instrument calibration was re-established through special spacecraft pitch maneuver on 9/16/2003 by looking directly at the Sun and deep cold space (3 K)
- Nonscanner SW sensor gain and offset were essentially unchanged between 9/1999 and 9/2003



ERBS Data Recovery Processes



Instrument Tilt Angle Determination

- The tilt angle is defined by the angle between the ERBE/ERBS nonscanner optical axes and the spacecraft nadir.
- This angle is critical for removing instrument artifact in the TOA SW fluxes

Total Solar Irradiance (Wm^{-2})

Date	Total	SW
~11/21/1984	1371.5	1353.1
*11/21/1984	1373.7	1354.0
~12/04/2002	1317.7	1194.3
*09/16/2003	1372.6	1244.1

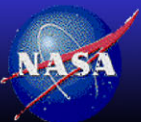
~ Azimuth setting of 0 degree

* Azimuth setting of 90 degrees

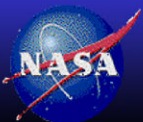
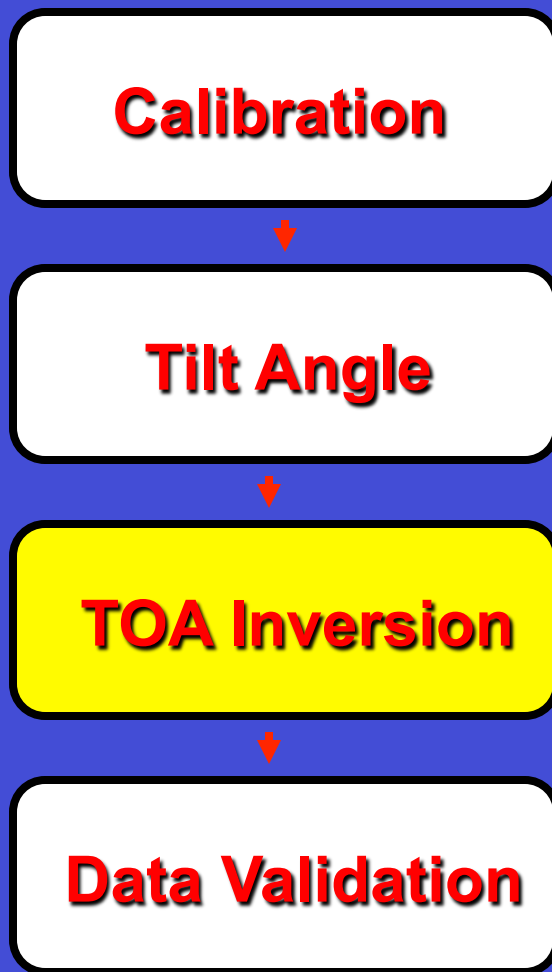
$$\text{Tilt Angle} = \text{Cosine}^{-1} (\text{TSI}_{2002} / \text{TSI}_{2003})$$

	Total	SW
Tilt Angle (Degree)	16.2	16.2

Consistent with each other



ERBS Data Recovery Processes



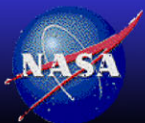
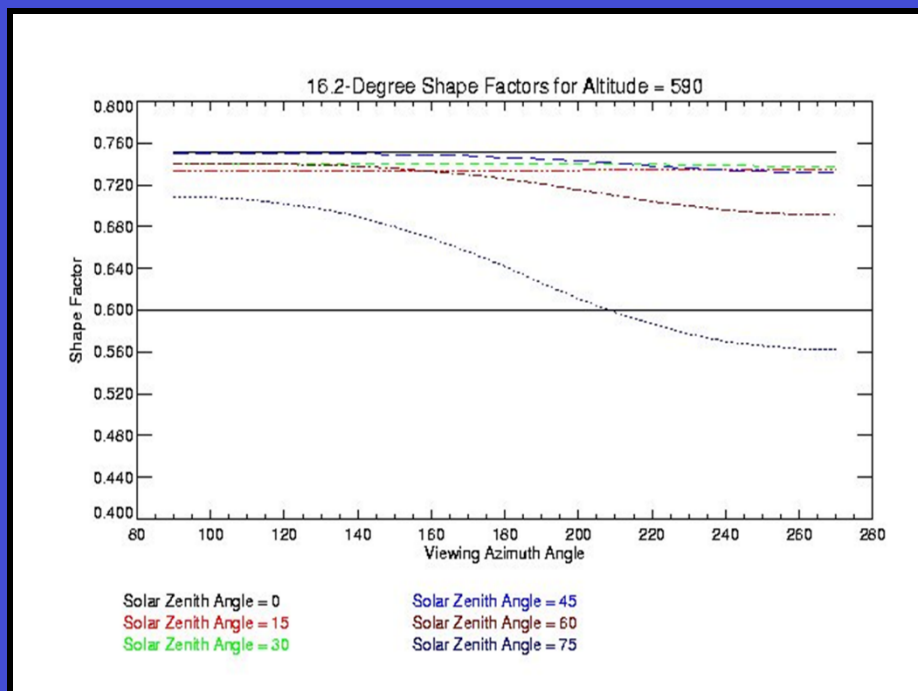
ERBS Nonscanner SW Inversion

- ERBS SW inversion algorithm inverts the SW measurement at satellite into SW flux at top of the atmosphere (TOA)
- SW_{toa} is determined by SW_{sat} , instrument tilt angle (ta), satellite altitude (alt), solar zenith angle (sza), and satellite relative azimuth angle (raa)

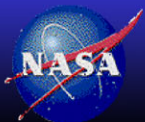
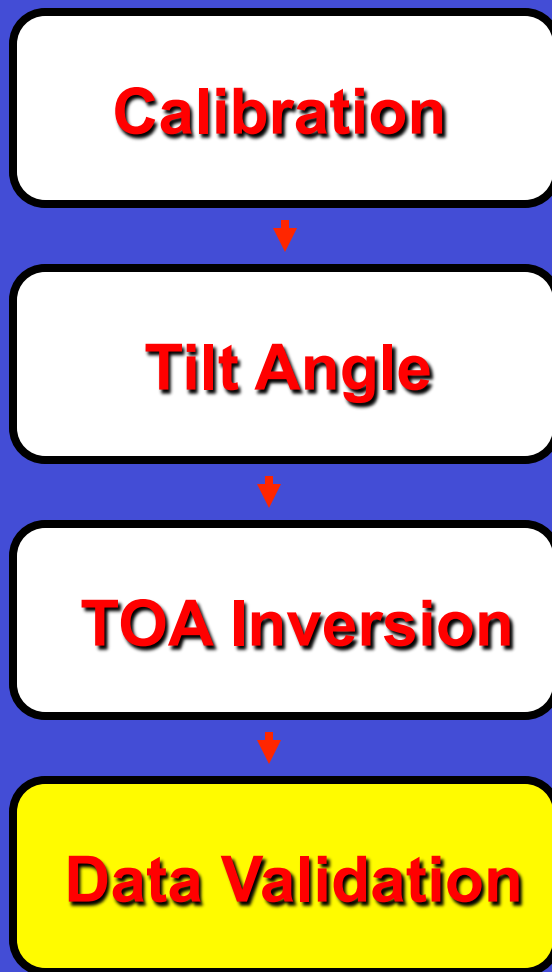
$$SW_{toa} = SW_{sat} / \text{Factor}(ta, alt, sza, raa)$$

	9/30/1999	10/6/1999
Factor	0.88	< 0.76

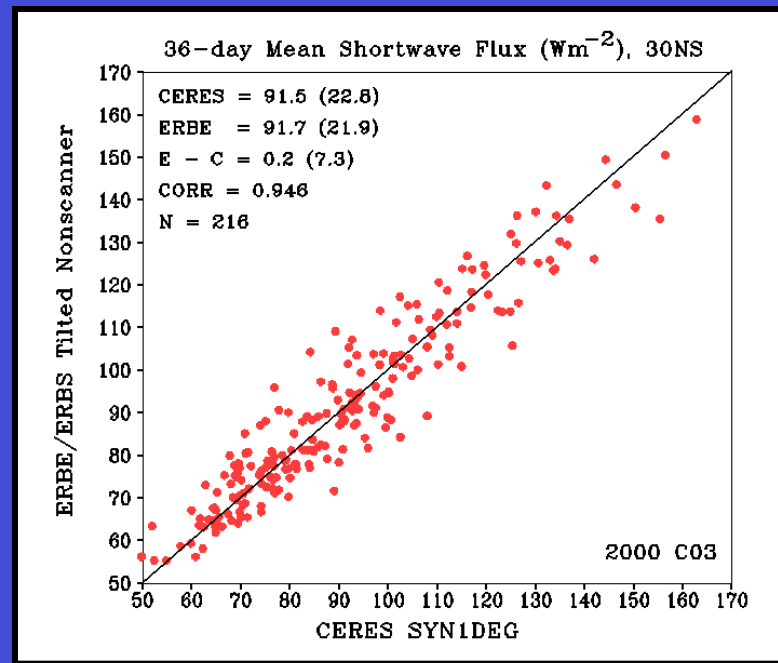
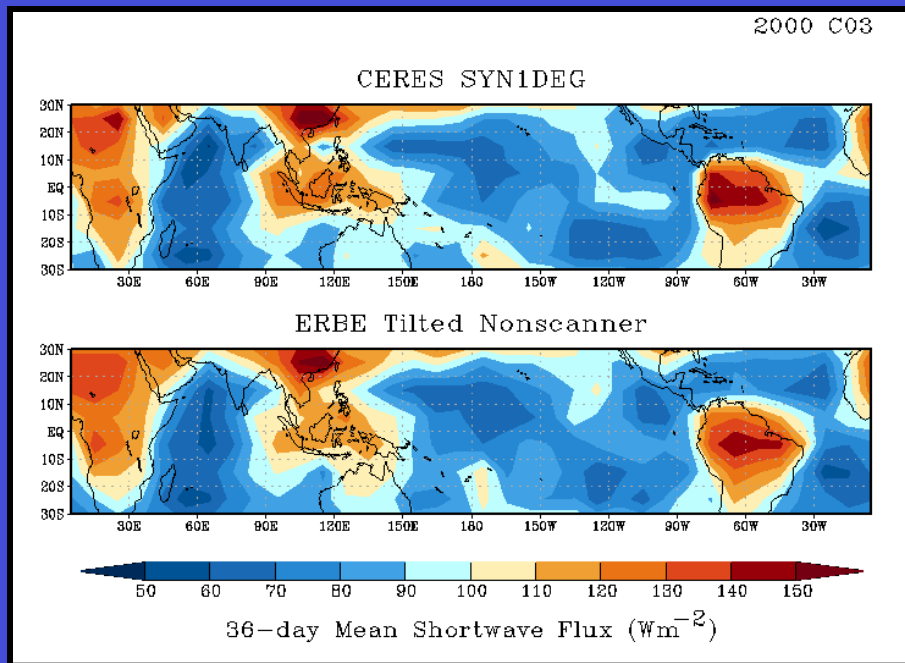
The lower value of the inversion
“Factor” will increase the SW_{toa}



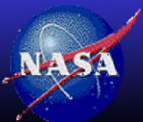
ERBS Data Recovery Processes



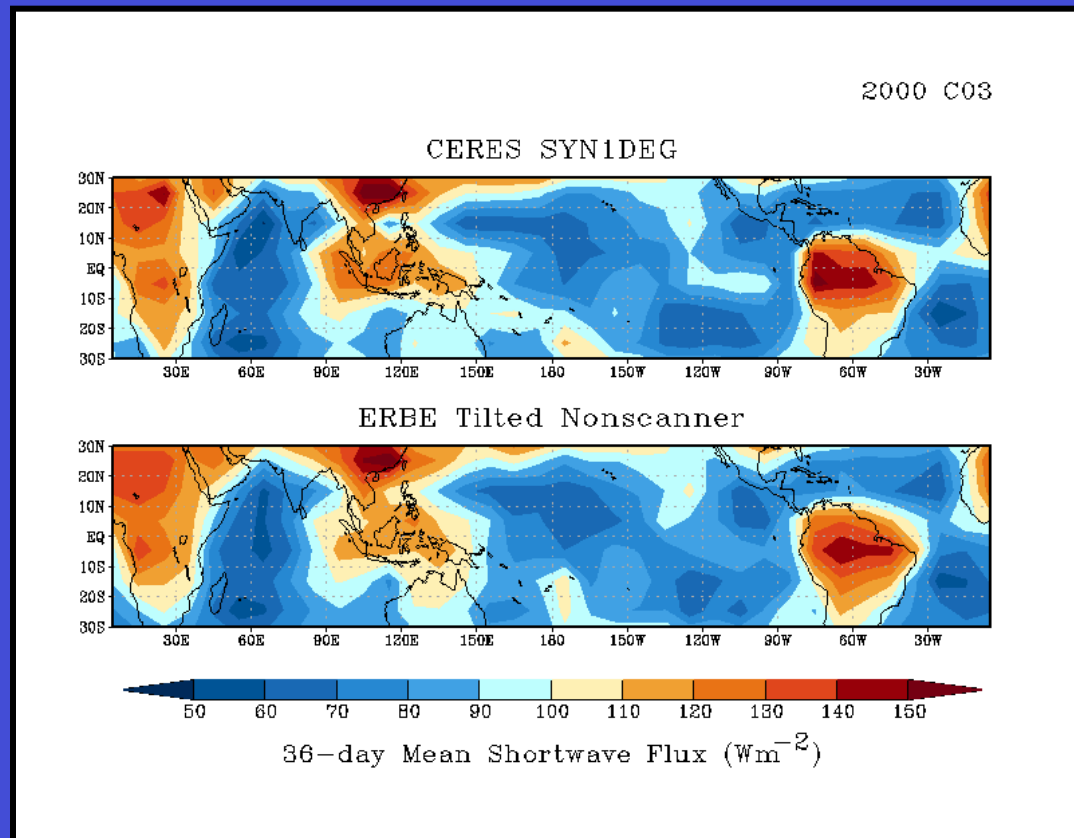
Regional Comparison: 36-day Cycle03 2000



Time	N	CERES	ERBE	E minus C	CORR
2000C03	216	91.5 (22.8)	91.7 (21.9)	0.2 (7.3)	0.946



Time-Space Comparison: 2000C03 to 2002C05

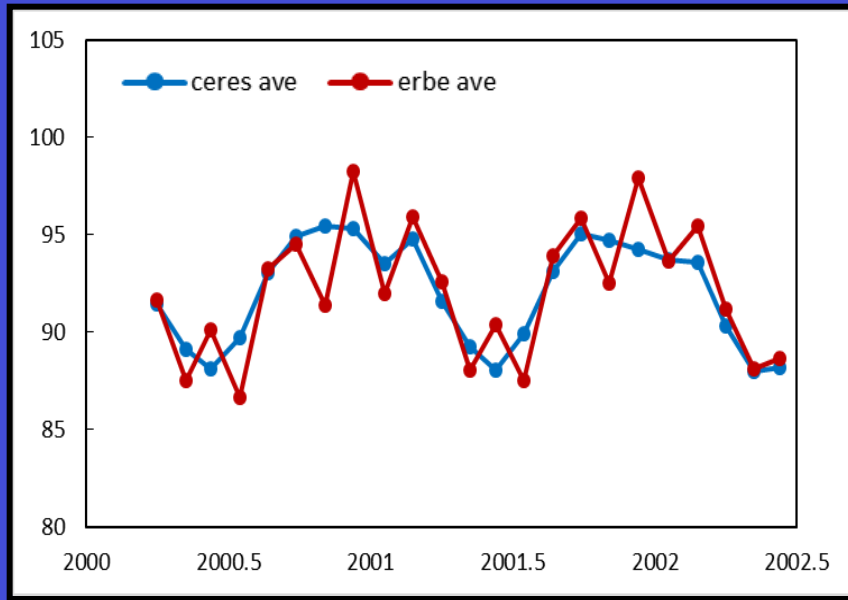


- The ERBS tilted nonscanner data matches well with the time-space pattern of CERES SYN1deg data; spatial correlation ~ 0.93 to 0.97

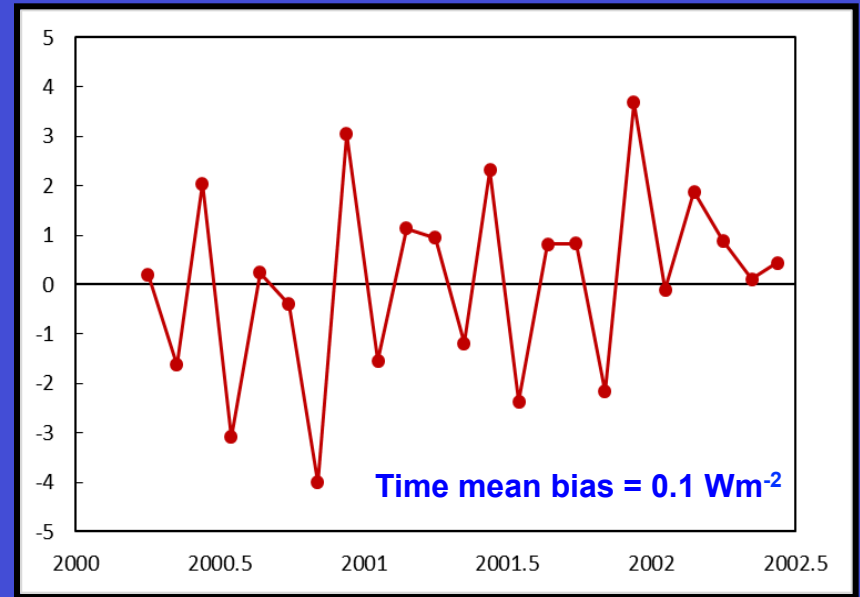


Tropical Mean Time Series: 2000C03 to 2002C05

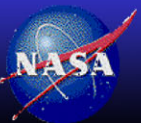
ERBE vs. CERES, 36-day mean (Wm^{-2}), 30NS



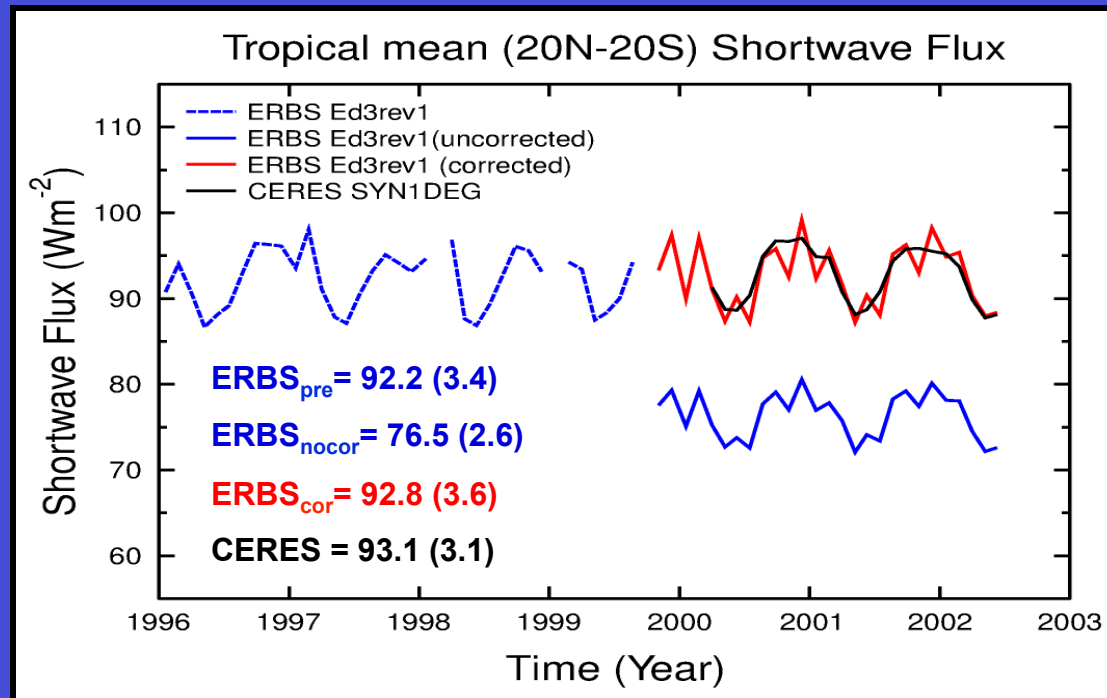
ERBE - CERES, 36-day mean bias (Wm^{-2}), 30NS



- The tropical (30NS) time series shows very good agreements between ERBS tilted nonscanner and CERES SYN1deg data
- The nonscanner data is a bit noisy with bias (ERBE-CERES) between -3 to 4 Wm^{-2} during the 2000-2002 period. Time averaged bias $\sim 0.1 \text{ Wm}^{-2}$



20N to 20S Mean Reflected Shortwave Radiation



- The revised algorithm moves the ERBS post-anomaly time series back to the same radiometric level as the pre-anomaly data
- The recovered ERBS nonscanner time series also matches well with the overlapping CERES SYN1deg data



Summary

- The recovery of the ERBS SW record from 10/1999 to 8/2005 is almost completed
- The SW calibration is determined to be unchanged between 9/1999 and 9/2003 based on solar and deep space view data
- The tilt angle is determined to be 16.2 degree from spacecraft nadir using solar calibration data
- TOA inversion algorithm is revised to take into account of both the tilt angle and the partial sensor FOV blockage by the instrument housing
- Time-space validation of the recovered ERBS record (3/2000 to 6/2002) with CERES SYN1deg data shows excellent results
- Additional validations for the remaining data (7/2002 to 8/2005) will be performed to complete this study

